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Devices and methods to measure H2 and CO2 concentrations in gases released from soils and low temperature fumaroles in volcanic areas

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Hydrogen solubility and diffusion have a great relevance to change the redox state of magmas, usually expressed by oxygen fugacity. This influences many chemical and physical properties, such as oxidation state of multivalent elements, kind and abundance of minerals and gas species. These processes change the phase ratios into the volcanic system and so the magma movement capability toward the earth surface and the eruptive dynamics.

In past studies several authors (Carapezza et al., 1980; Sato et al., 1982; Sato and McGee, 1985; Wakita et al., 1980) proposed the application of the fuel cells in order to measure reducing capacity of volcanic gases. Their found some clear correlations between variation peaks and volcanic activity but a few reducing capacity changes showed no correlation with it.

In this study we characterize a fuel cell device designed to measure hydrogen concentration in a gas mixture. We present test results obtained in laboratory and in field trip, carried out to verify the major interferences of others reducing gas species, commonly present in volcanic emissions, in the measurement carried out with a hydrogen fuel cell sensor. Tests were performed at controlled temperature ad pressure conditions and at air saturated pressure vapour in the cell cathode.

A new device to measure simultaneously hydrogen (H2) and carbon dioxide (CO2) concentrations in soil and in low temperature fumaroles in volcanic areas was proposed. The H2-detector is a hydrogen fuel cell, whereas CO2 is measured using an I.R. spectrometer. To build a continuous monitoring station of volcanic activity both sensors were put in a case together with a data logger. Our device has 0.2 mV ppm-1 sensitivity, accuracy of ± 5 ppm and about 10 ppm resolution whit respect to the hydrogen concentration. These instrumental characteristics were obtained applying a 500 ohm resistor to the external circuit that represents the best compromise between sensitivity, resolution, instrumental response time, and linearity of signal. We determine the CO2 concentration in the gas mixture with an I.R. spectrometer that has a measuring range of 0-100% with accuracy of ± 2% of the range and response time of 10 seconds.

The laboratory results confirm our hypothesis of interference between H2, H2S and CO in the full concentration range of contaminant species. Therefore, according to our studies, the assignment of the fuel cell signal output variations only to H2 variation of concentration as in past studies, without physical separation of different reducing species may be misleading.

Continuous measurements and periodical measurement field trip were performed at Torre Del Filosofo site on the upper part of the Etna volcano from the end of July to the middle October 2008. In field applications, H2S was removed with a Pb(COOH)2 trap whereas CO interference was neglected because H2/CO ratios in volcanic gases are typically high. Field time-series measurements of H2 and CO2 in gases emitted by low temperature fumaroles at Torre del Filosofo site showed a close positive correlation between explosion activity and the major peaks in the hydrogen concentration.